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Author: Prof. Lyudmila Kuzmina
Kazan National Research Technical University, Russian Federation

SOME METHODS FOR MODELLING MULTI-SCALE SPACECRAFTS DYNAMICS WITH SGS

Abstract

Main aims of the research are general problems of mathematical modelling and analysis for complex technical objects that are related to aviation/aerospace systems, for systems of gyrostabilization (SGS). Special attention is attracted to the conceptual points and methodology for solving decomposition problem in dynamics of the spacecrafts of different classes (with multi-scale dynamics of small or big stabilized objects). The proposed methodology is based on developing classical statements of A.M.Lyapunov, N.G.Chetayev in stability theory for decomposition problems of complex multidisciplinary model of singularly perturbed class. Besides the constructing approximate models is realized by strong mathematical manners. It is conforming the original thesis of I.M.Gradstein about close connection between A.M.Lyapunov stability theory theorems and the results of the differential equations theory with small parameters, that are the direct consequence of stability theory theorems. Such points are allowing to construct the effective algorithm for reduction-decomposition of original complex model. Special interest in this is the decomposition of dynamic properties including fast - operating, optimality ones. Established unified approach gives the possibility to obtain the reduced motion equations and shortened models as asymptotic nonlinear s-approximations that will be acceptable in analysis , synthesis, control. From stability theory point it is some generalization of A.M.Lyapunov linearization method and reduction principle. Elaborated method has the brilliant applied results in general theory of multiscale systems of gyrostabilization (SGS), orientation, navigation (K.Magnus, D.R.Merkin, A.Yu.Ishlinskiy, P.A.Kuzmin, B.V.Raushenbakh). Besides it is revealed the necessity to consider separately the spacecrafts of different classes (with multi-scale dynamics, for small or big stabilized objects). In case of fast gyroscopes (mathematical model with big parameter) it leads to the decomposed equations of motion (to approximate theories, including elementary gyroscopes theory) as s- asymptotic models. In dynamics of small spacecrafts it is revealing new acceptable asymptotic models, with separation of stabilization channels in nonlinear statement. But in dynamics of big stabilized objects it is revealed another decomposition, with other asymptotic models and conditions of acceptability. Here the modelling of engineering systems is carried out as Art. This study is implemented with RFFI support (15-08-00393).